Metabolic Profiling of dairy cows to improve efficiency and production

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- The time just before and just after birth is very demanding for animals in terms of energy.
- Inadequate management during this period can often cause serious and costly diseases.
- Metabolic profiling may be used as a diagnostic tool or in the prediction of disease risk to help prevent or treat economically significant diseases (ketosis, fatty liver, milk fever *etc.*).
- Metabolic profiling is becoming more cost-effective as technology develops, and pooled sampling can be used to reduce test costs while obtaining in-depth data.

The metabolic profiling of an animal involves analysis of blood to evaluate internal functions and how these might affect the animal as a whole. The results are used to assess the nutritional state and fertility of animals, particularly those in the "transition period" – this is the time 3 weeks before and 3 weeks after birth. This information can then be used in the diagnosis and prediction of diseases in the herd, for example, milk fever, mastitis and fatty liver syndrome.

Metabolic profiling requires a simple blood draw from animals. The time of sampling relative to feeding is important, as feeding management should be consistent across animals to ensure accurate, reflective results. The blood is then analysed to assess levels of substances linked to significant diseases and health problems. The initial metabolic profile test introduced in the 1970s was used for many years to assess the metabolic status of individuals and groups but has been improved upon to give a more modern diagnostic process that is able to cope with large herd sizes and provide more accurate and cost-effective analysis. It is also important to note that a metabolic

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profile should be combined with other information including herd and animal records, facilities and rations to ensure its effectiveness as diagnostic tool.

Biological Principles

The transition period is an exceptionally important stage in which the animal's metabolism is key, as disruptions and imbalances can lead to metabolic disorders (*e.g.* milk fever), infectious diseases (*e.g.* mastitis) and issues with future reproductive performance (*e.g*. fertility). Environmental factors can also have an effect on the animal's physical ability to cope during the transition period, such as over-crowding, changing social organisation, and heat stress as animals change the way they use nutrients, which may lead to deficiencies.

There is great energy demand during the transition period, from the growing foetus (sometimes two), the labour and birthing process and for production of colostrum and milk. Such demands often cause animals to go into a Negative Energy Balance (NEB) where the animal uses more energy than what it is taking in. Whilst this is a normal temporary response, severe cases can cause problems. This lack of energy tends to occur soon after calving when feed intake is low (approx. 30% decrease from normal) and energy demand for milk is high. This causes reserves of body fat to be broken down. Breakdown results in an accumulation of Non-Esterified Fatty Acids (NEFA) in the blood, which are used for energy by the liver. The liver, however, can only use so much NEFA, so high levels will cause fatty liver syndrome. Fatty liver impairs the normal liver function and can cause low blood glucose (hypoglycaemia). Another result of this fat breakdown is the production of ketones; these by-products do occur naturally in the body, but high levels can cause serious health problems like ketosis.

β - hydroxybutyrate (BHB) is one such ketone, which is widely used in diagnostic tests and metabolic profiles. However, it should be noted that BHB levels could be influenced by dietary sources such as poor-quality silage so it is important to rule this out before investing in treatments. Animals with ketosis have significantly higher odds of developing a displaced abomasum and metritis (inflammation of the uterus), combined with reduced fertility and milk production. A displaced abomasum generally occurs because of calving, when the uterus pushes the abomasum out of place during pregnancy, although the two are not directly connected BHB levels can be used in risk evaluation for displaced abomasum. Elevated levels of BHB also increase susceptibility to infection, reduce milk yield, impair reproduction and increase the risk of culling.

Protein levels in the body can also be used as indicators for disease around transition time. The most accurate measurement of protein is by testing several factors: Blood Urea Nitrogen (BUN), creatinine, total protein and albumin. Each measurement can be used in different diagnoses, for example, creatinine levels can be used to assess kidney function whilst total protein and albumin reflect the availability of protein and can indicate deficiencies in the diet. These measurements are useful, as low albumin levels have been linked with a three-fold risk of disease after birthing in dairy cows – a costly problem for all dairy farmers. Protein measurements will vary depending on the status of the animal *i.e.* if she is dry, close-up or fresh (Table 1); nevertheless, this is useful data as deficient cows become significantly more susceptible to infection and require expensive antibiotic therapy.

Body condition scoring (BCS) has also been linked to the performance of internal functions and hormone levels. At a low, underweight BCS (1.25 and 2) tests revealed lower glucose levels and higher amounts of NEFA. At a high, overweight BSC (4+), high insulin and urea levels have been recorded. As such, BCS can be used as a reliable parameter when selecting which animals to profile and when assigning animals to groups for testing.

Mineral levels play a key role in many important diseases of the dairy cow, for example, milk fever (hypocalcaemia), alert downer cows (recumbency) and weak cow syndrome. The most informative minerals levels are calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg) and sulphur (S), however, it must be noted that these minerals are also carefully balanced by internal functions of the animal. Never the less, P, K, Mg and S are used as reliable indicators for kidney failure and digestive problems. Assessment of Ca concentrations around the transition period can be extremely useful in predicting cases of milk fever as research has found that cows with low calcium levels were four times more likely to develop *postpartum* disease.

Most common measurements used to create a metabolic profile are levels of BHB, albumin, calcium, magnesium, sodium and NEFA, each of which are uniquely linked to transition diseases and will present the farmer with a comprehensive overview of the individual and/or herd.

Value and Implementation

The implications of unresolved or severe NEB include an increased risk of metabolic diseases and infections in addition to losses in productivity and therefore in profit. Losses in productivity result in the reduction in milk production, the loss of milk during antibiotic treatment, veterinary fees and possibly the cost of culling an animal. Estimates state that the treatment of milk fever alone can cost up to £250 per case, which at a 7% incidence rate, equates to approximately £1,750 for a 100-cow herd. Using milk fever as an example, subclinical cases can be even more costly in the long term as the disease is not recognised and causes further problems (*e.g.* a displaced abomasum where treatment costs up to £600 per case).

As a rule, preventative measures are better than treatment, by providing the correct diet tailored to the animal's physical state with adequate feeding space to maximise dry matter intake (DMI). For example, altering the mineral content of rations to reduce milk fever requires adequate magnesium levels and low potassium content for cows in the dry period. Maintaining a good BCS (around 3) can also work to prevent problems during transition. In the long term, providing high quality nutrition and profiling animals is extremely cost effective when compared to the price of treatment for already sick animals, losses in productivity and the cost of needing to cull.

There are two main reasons for metabolic profiling in livestock: as a diagnostic tool for a specific disease or for a metabolic profile of the herd. Essentially, this is the difference between sampling a small population of affected animals to diagnose a disease versus the collection of samples from "normal" individuals to identify disease risk and nutrient status (Table 1).

Group	**Time relative to calving**
Far Off Dry	>10 days following dry off & <30 days prior to calving

Close-up Dry	3-21 days prior to calving (ideally 3-14 days)
Fresh	3-30 days in milk (ideally 2-21 days)
Lactation	Defined as needed based on disease condition or production level

Table 1: Examples of physiological groups used in metabolic profiling and their time relative to calving.

Using "pooled" samples can also help make the process more cost effective and is generally useful when screening for disease risk in the herd. The optimum number of individual samples ranges between 5 and 10. For example, six samples may be taken from each group in Table 1, resulting in 24 samples, these may then be analysed individually to provide a herd profile. Alternatively, the six samples per group may be pooled (mixed under laboratory conditions), resulting in just three samples that contain blood from 18 individuals.

Summary

In the past, cost and interpretation of metabolic profiles have been a limiting factor, but as technologies have developed, it has become more economically viable to profile animals. Research has shown metabolic profiling to be highly effective when coupled with the correct treatment (mostly dietary management) in reducing disease during the transition period. Numerous research studies have uncovered the internal changes that happen during the transition period and their role in health-related problems. It is important that this information is put to good use on the farm to increase productivity and profitability, as well as the health and welfare of livestock.

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Note to editors:
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